AD-A120 098 WESTINGHOUSE RESEARCH AND DEVELOPMENT CENTER PITTSBU--ETC F/G 20/5
MERCURY BROMIDE LASER DISCHARGE LIFE STUDIES.(U)
AUG 82 C S LIU, I LIBERMAN N00014-81-C-0485

UNCLASSIFIED NL

1 OF 1
AD A
120098

END
DATE
FILMED
11 82
DTIC

AD A120098

DTIC FILE COPY

12

MERCURY BROMIDE LASER DISCHARGE LIFE STUDIES

C. S. Liu and I. Liberman

Final Report
Report Period Covered
May 1, 1981 to January 31, 1982

Contract No. N00014-81-C-0485
Office of Naval Research

August 3, 1982

Westinghouse R&D Center
1310 Beulah Road
Pittsburgh, Pennsylvania 15235

MERCURY BROMIDE LASER DISCHARGE LIFE STUDIES

C. S. Liu and I. Liberman

Final Report
Report Period Covered
May 1, 1981 to January 31, 1982

Contract No. N00012-81-C-0485
Office of Naval Research

August 3, 1982

Westinghouse R&D Center
1310 Beulah Road
Pittsburgh, Pennsylvania 15235

MERCURY BROMIDE LASER DISCHARGE LIFE STUDIES

C. S. Liu and I. Liberman
Westinghouse R&D Center
Pittsburgh, PA 15235

ABSTRACT

This report summarizes research work performed at the Westinghouse R&D Center under ONR Contract No. N00014-81-C-0485 for the period between May 1, 1981 and January 31, 1982. The major effort was to perform experimental lifetime studies of the HgBr laser system, and to verify noble metal electrodes for long life operation in HgBr laser discharges.

In this report, the results of experimental life tests of gold and platinum electrodes for HgBr lasers are presented. The life expectancy of such electrodes is over 10^8 shots or 300 hours at 100 pulses per second. The possibility of extending its life to 10^{10} shots is discussed.

TABLE OF CONTENTS

LIST OF FIGURES

MERCURY BROMIDE LASER DISCHARGE LIFE STUDIES

C. S. Liu and I. Liberman
Westinghouse R&D Center
Pittsburgh, PA 15235

1. INTRODUCTION

This report summarizes research work performed at the Westinghouse R&D Center under ONR Contract No. 00014-81-C-0485 for the period between May 1, 1981 and January 31, 1982. The major effort was to perform experimental lifetime studies of the HgBr laser system, and to verify noble metal electrodes for long life operation in HgBr laser discharges.

During the past year, we made screening studies of material compatibility on the basis of the thermochemical calculations[1] and RF discharge experiments.[1] Several metals such as noble metals appeared to be suitable as electrode materials. However, these studies could not totally simulate the real HgBr laser discharge conditions, since specific HgBr decomposition product reactions can easily make these experimental results invalid. We, therefore, constructed a small scale HgBr laser discharge test cell to duplicate the identical discharge conditions of a 100 pps HgBr laser and to lifetest the gold and platinum electrodes for HgBr lasers.

In this report, we will describe the construction of HgBr laser discharge cells and present lifetest data (up to 10^8 shots). Finally we will discuss some of the life problems associated with a 10^{10} shots HgBr laser and recommend future studies which will lead to a possible design for a future 10^{10} shots HgBr laser.

2. EXPERIMENTS AND RESULTS

A high repetition rate self-sustained glow discharge was obtained in $HgBr_2$ vapors using Ne/N_2 as buffer gases at temperatures up to $200^{o}C$. These pulsed transverse discharges preionized by UV spark sources placed inside of discharge cells, were diffuse and had dimensions of 1 cm in diameter and 1 cm electrode spacing. At temperatures above $150^{o}C$, the fluorescence of the discharge was identical to that of actual HgBr lasers. The test cell was operated under similar gas compositions, power loading and operating temperature of an actual HgBr laser. The optical and V-I characteristics were monitored to ensure a duplication of the discharge conditions of HgBr lasers.

The laser discharge cell (see Figure 1) was fabricated entirely from glass with nonex-tungsten feedthroughs. The discharge gases were circulated between two cencentric cylinders with the assistance of a magnetic coupled glass fan. The electrodes were made of profiled nickel and the preionization was generated from a spark between two platinum wires. Electric feedthroughs, supporting structures and electrodes were all gold plated. In addition, the front surfaces of both electrodes were capped with 5 mil pre-selected metal foils (Au or Pt).

The discharge cells and electrodes were carefully cleaned and baked under high vacuum. The tubes were loaded with doubly sublimed $HgBr_2$ powder through break-up ampules, evacuated to 10^{-5} Torr and $HgBr_2$ sublimed a third time. After backfilling with 50 Torr of nitrogen and 650 Torr of Neon, the tube was sealed off from the vacuum system and inserted in a temperature controlled oven for testing.

The operating conditions for the tests were at a pulse repetition rate of 100 Hz, input power density of 0.1 J/cc and an operating temperature of $170^{o}C$. During the entire lifetest, an optical multichannel analyzer was used to monitor and to compare the discharge fluorescence of the test cell

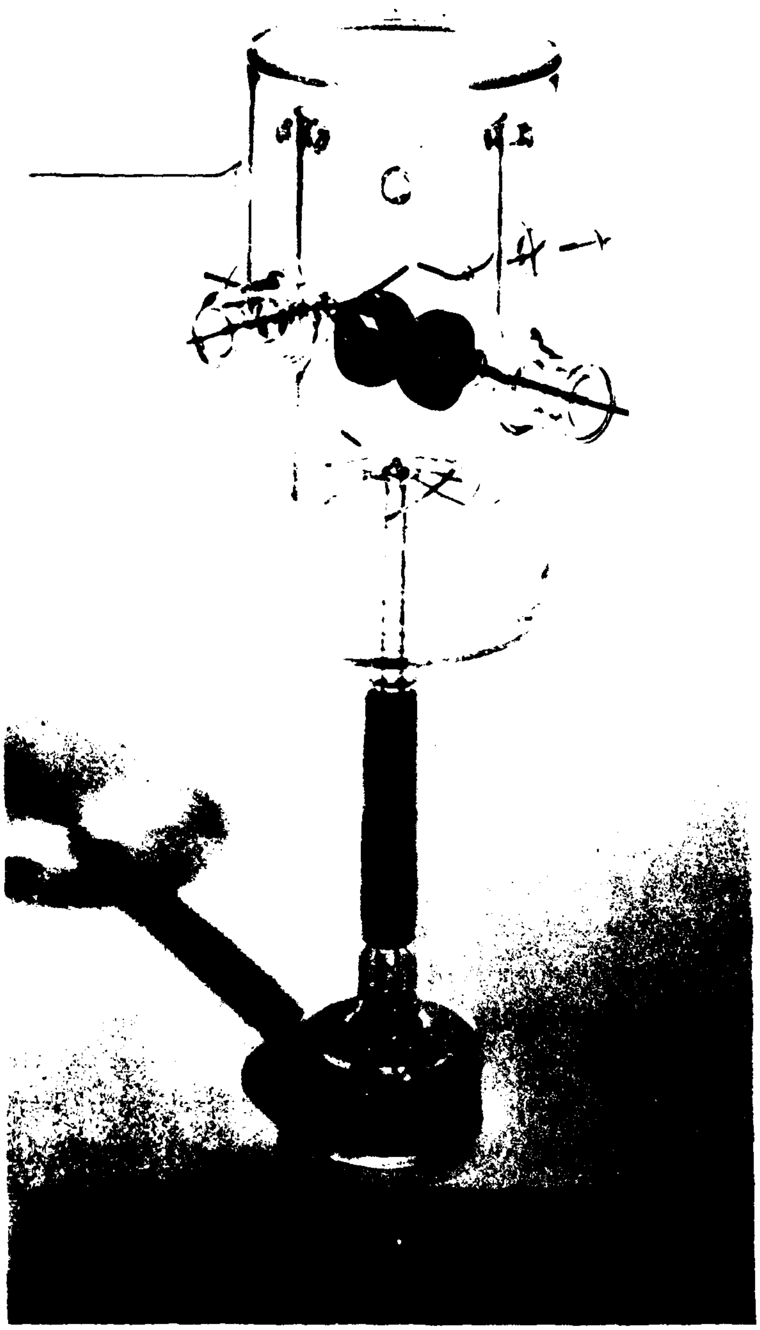

Figure 1 - HgBr Laser Discharge Test Tube

with HgBr laser side light fluorescence shown in Figure 2. The HgBr fluorescence changed very little throughout the entire test but an increase in black deposit on the wall of the inner cylinder became noticeable toward the end of the test. Post test analyses of the black deposit on the wall indicated that the gold and platinum were sputtered off from the electrode surfaces at rates of ~10 μg per coulomb determined by weighing the 5 mil electrode caps before and after the life test. There are two possible mechanisms for the electrode weight loss: 1) pure ion sputtering, and 2) mass transport due to chemical transport reactions. The rates of electrode weight loss varied from a few μ-gram per coulomb for platinum electrodes to about 20 μ-gram per coulomb for gold electrodes. For a one joule (at 20 kV capacitor changing voltage) HgBr laser, a total of one kilogram electrode material will be sputtered off in 10^{10} shots. A special design of the laser tube to prevent coating of the optics and shorting of the electrical circuitry would be required. The electrode sputtering rate will decrease with increasing buffer gas pressure. Since a high energy HgBr laser is usually filled with over 4 atm neon,[2,3] it shoud have lower rate of electrode weight loss and the laser should survive 10^8 shots even without any complicated tube structures.

The lifetest of the laser discharge cell was terminated when the accumulated life reached 10^8 shots. The dark deposits on the inner walls of the discharge tubes were analyzed by ESCA (Electron Spectroscopy for Chemical Analysis). The results indicated that most of the deposit was either sputtered off from the electrode surfaces or chemically transported from the electrode. However, both the gold and the platinum were detected as elemental forms unlike nickel and rhenium which were found in both compound and elemental forms. Since there was no measurable formation of bromides from the noble metal electrodes, depletion of $HgBr_2$ should not be a problem for properly made HgBr lasers. It is very important to note that isothermal operation (uniform temperature) and an oxygen/moisture free environment are essential for preventing chemical transport reactions which can be a life limiting factor for a HgBr laser.

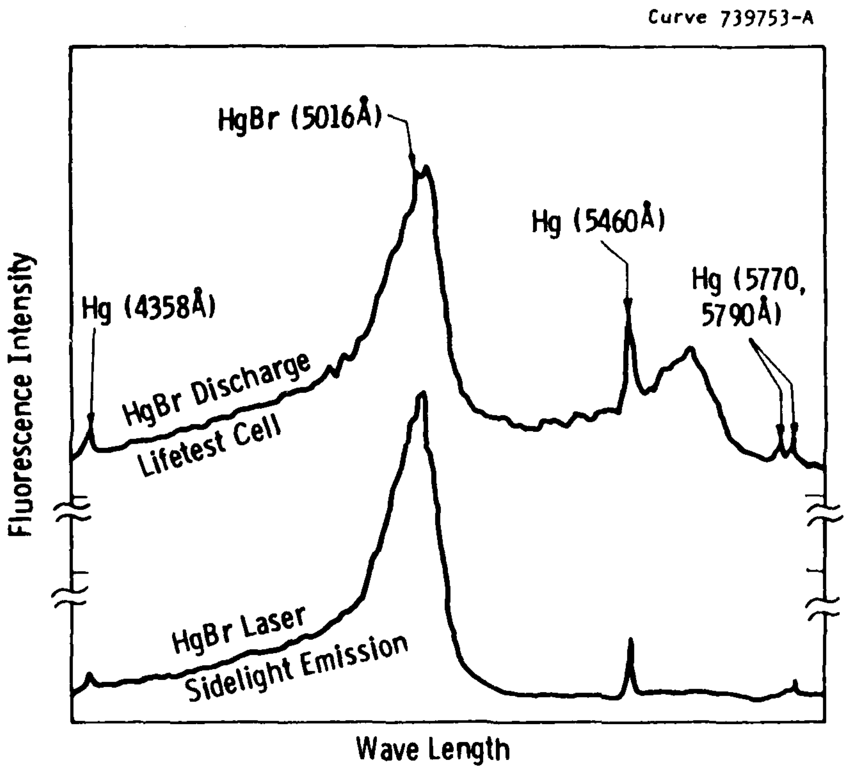

Figure 2 - $HgBr_2$ Discharge Fluorescence Spectra

The electrode surfaces were analyzed using an Auger spectrometer. The results of the Auger analyses of gold and platinum electrodes are shown in Figures 3 and 4 in which the atomic percentages of the mercury detected are plotted versus depth into the electrode surface. As indicated by the data, the anodes were free of Hg attack but the first 100 Å in the cathode surface of either gold or platinum electrode contained some Hg. Because the mercury were only found in the cathode but not in the anode it leads us to believe that the embedded Hg might be due to Hg ions implanted into the cathode surface by the electrostatic force. Although the Hg penetration into the cathode was very shallow, the actual effect on the HgBr laser life is unknwon. We are in the process of lifetesting a small high repetition rate HgBr laser with platinum foil capped electrodes and with gold plating of all metallic parts in the laser tube. From this test we will be able to assess the actual life of these HgBr lasers and re mmend future work for improving the life of such lasers.

Curve 739755-A

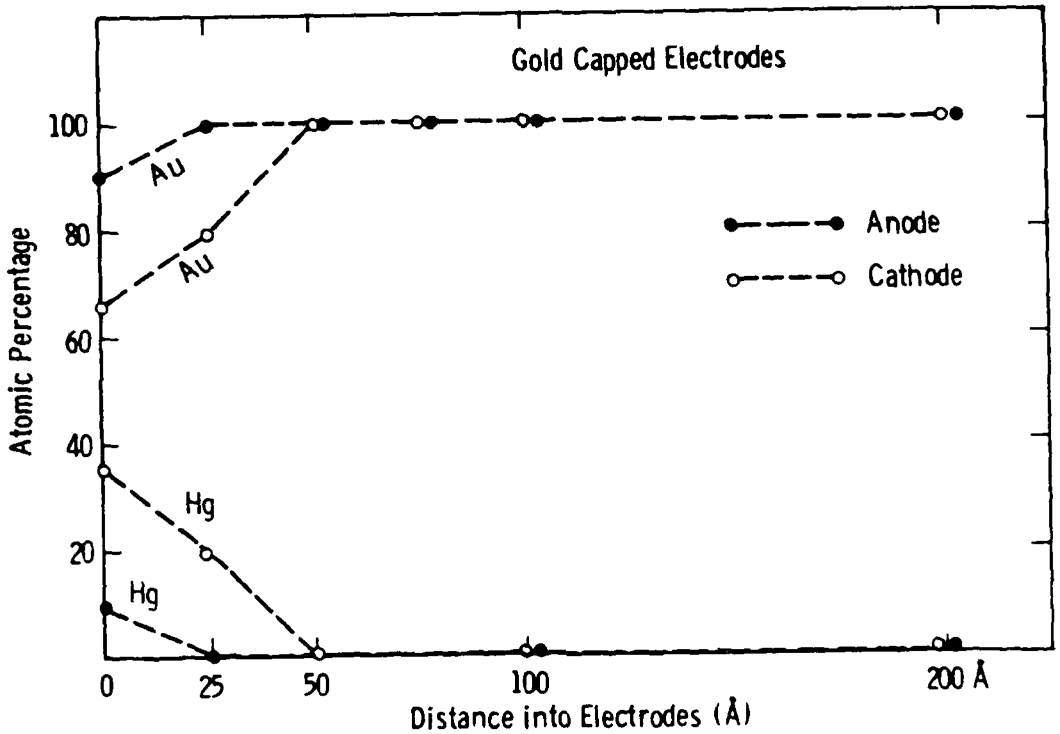

Figure 3 - Results of Auger Analysis on Gold Electrodes

Curve 739754-A

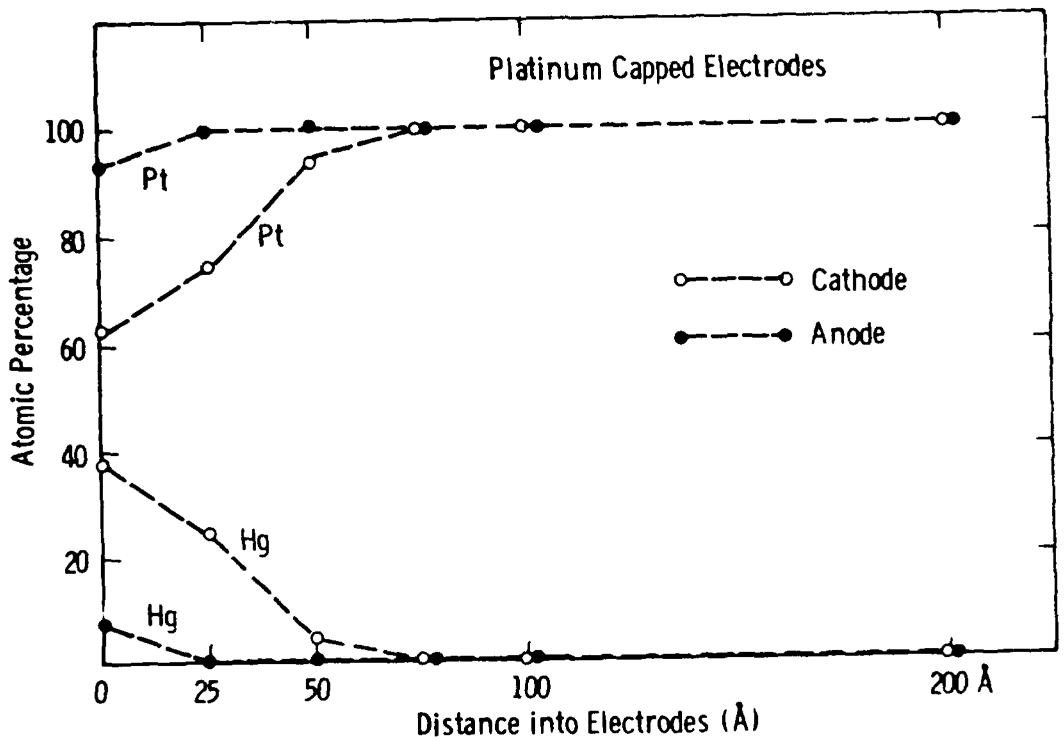

Figure 4 - Results of Auger Analysis on Platinum Electrodes

3. SUMMARY AND RECOMMENDATIONS

Based on the results of our HgBr laser discharge lifetesting studies which were in agreement with our thermochemical calculations and compatibility experiments, the gold and platinum were shown to be quite inert to the HgBr laser environment. However, the electrode weight loss due to sputtering at $\sim$10 μg/coulomb can limit the operating life of HgBr lasers. Especially for the requirement of 10^{10} shots life, a new electrode material with lower sputtering rate or with a recovering system must be used.

We are encouraged about the test results of our laser discharge experiments, and we are in the process of conducting a lifetest of a small 100 pps HgBr laser. From this test we will be able to address the critical issues of how to improve the life of HgBr lasers.

4. REFERENCES

1. C. S. Liu, S. G. Leslie, D. W. Feldman and C. Hirayama, "Lifetime Study of HgBr Lasers," Final Report (July 1980 to March 1981) DARPA/NOSC Contract No. N66001-80-C-0319.

2. J. L. Pack, D. W. Feldman, C. S. Liu and I. Liberman, "Parameterization Studies of Discharge Excited HgBr Laser System," Proceedings of the International Conference on Lasers '80, December 1980.

3. C. H. Fisher, I. Smilanski, T. A. Znotins, P. E. Cassady, T. R. Burkes, and J. J. Ewing, "Scaling of X-ray Preionized HgBr Lasers," Technical Digest, Conference on Lasers and Electro-Optics, April 1982.

DATE
ILME